Detector Design and Prototyping for the PROSPECT Short-Baseline Reactor Experiment

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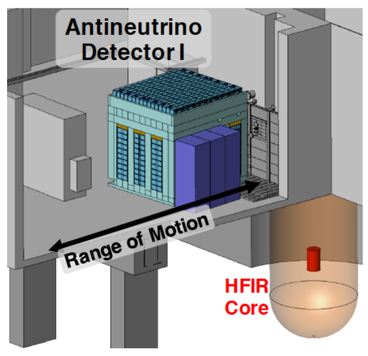
See also: P03.054, P03.055, P03.056

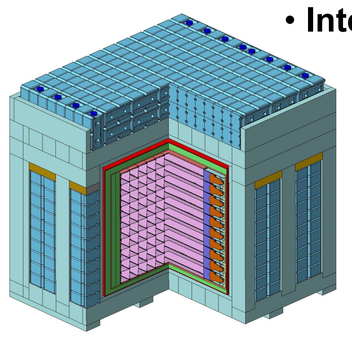
PROSPECT Segmented ^{6}Li-Loaded Antineutrino Detector Design

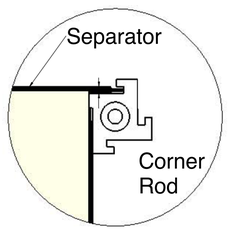


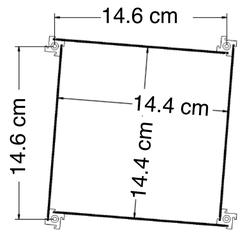
The PROSPECT Short-baseline experiment will operate a compact antineutrino detector (AD-1) 6-12m from a research reactor core

PROSPECT AD-1 Detector Features:

- **3 ton 6Li-loaded liquid scintillator (^{6}LiLS) target**
- **Low mass optical separators provide 120 optical segments, 117.5x14.6x14.6cm^3**
- **Double-ended PMT readout**
- **Internal calibration access along full segment length**



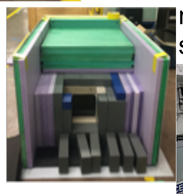




PROSPECT Detector and Shielding Development

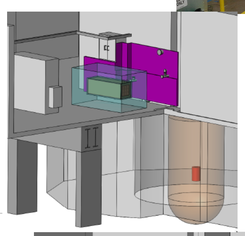
PROSPECT-0.1
Characterize LS
Aug 2014-Spring 2015
5cm length
0.1 liters
LS, ^{6}LiLS

PROSPECT-2
Background studies
Dec 2014 - Aug 2015
12.5 length
1.7 liters
^{6}LiLS



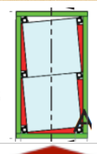
multi-layer shielding

PROSPECT-20
Segment characterization
Scintillator studies
Background studies
Spring/Summer 2015
1m length
23 liters
LS, ^{6}LiLS

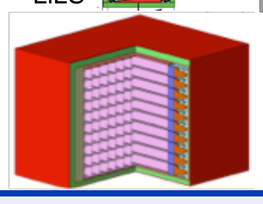


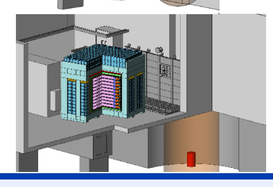
local reactor shielding

PROSPECT-50
Baseline design prototype
Spring 2016
1x2 segments
1.2m length
50 liters
^{6}LiLS



PROSPECT AD-I
Physics measurement
2017
10x12 segments
1.2m length
~3 tons
^{6}LiLS





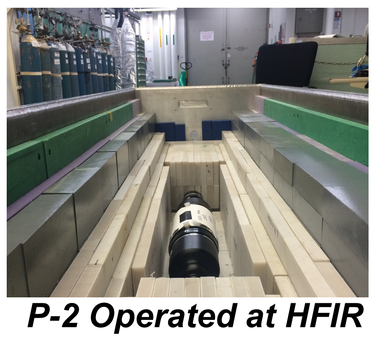
PROSPECT-0.1 & PROSPECT-2: Validation of ^{6}Li-Loaded LS & Shielding Performance

^{6}LiLS candidates tested in P-0.1

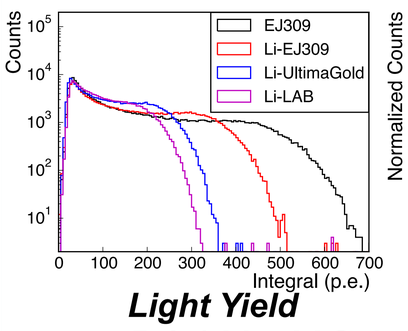
- **two viable formulations with good light yield and PSD identified**

P-2 deployed in tailored shielding at HFIR

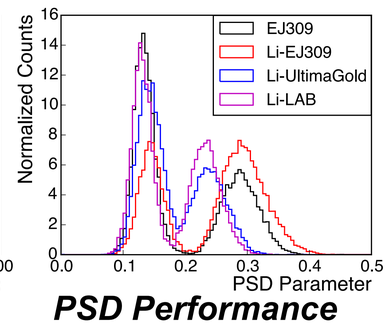
- **Verified ^{6}LiLS & shielding background rejection capabilities**



P-2 Operated at HFIR

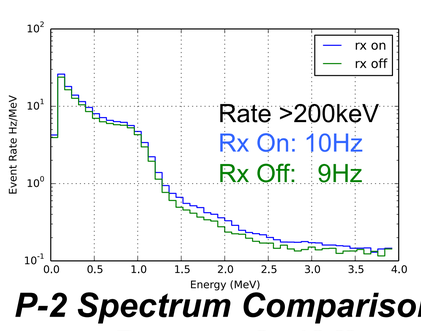


Light Yield



PSD Performance

P-0.1 Liquid Scintillator Comparison



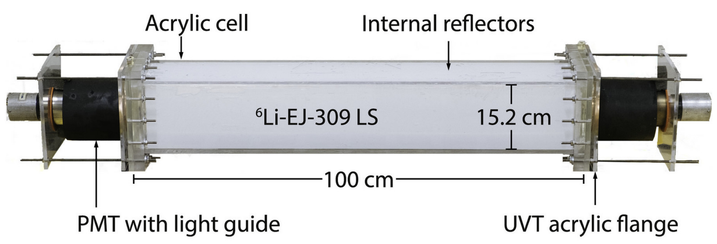
P-2 Spectrum Comparison Reactor On/Off

PROSPECT-20: Validation of Full-Scale Segment Performance

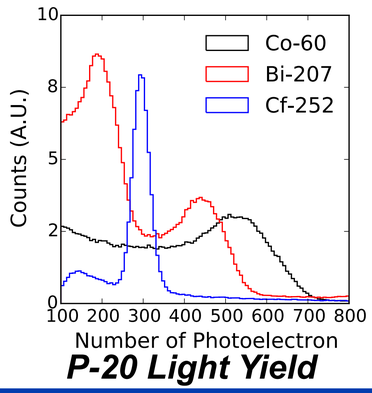
Demonstrates performance of ^{6}LiLS in PROSPECT geometry

- **Measured Light Collection:**
  > 530 PE/MeV
- **PSD Figure of Merit:**
  1.4 at (n,^{6}Li) capture peak

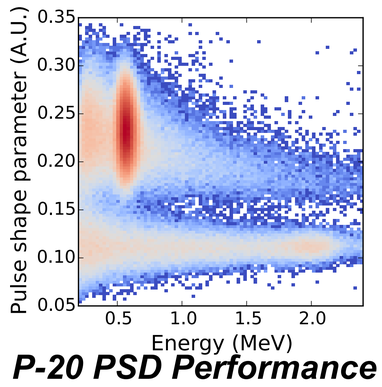
Surpasses Design Goals



P-20 Operated at HFIR

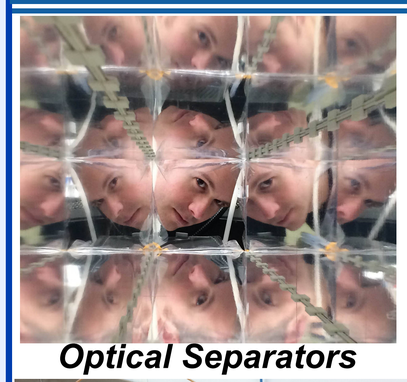


P-20 Light Yield



P-20 PSD Performance

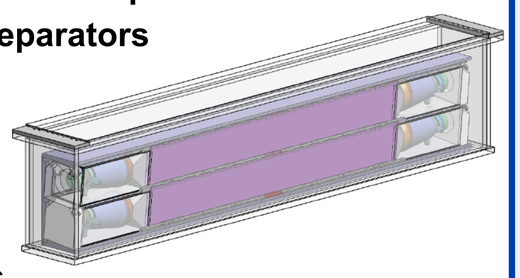
PROSPECT-50: Validation of AD-I Mechanical & Optical Design



Optical Separators

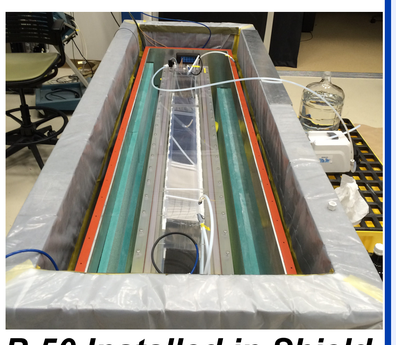
Uses AD-1 Design for all Components:

- **Low-mass Optical Separators**
- **Support Structure**
- **PMT modules**
- **Filling System**
- **Calibration System:**
  - **LED & γ/n Sources**



PMT Modules

Segment Assembly

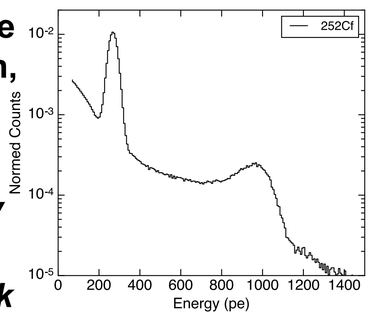


P-50 Installed in Shield

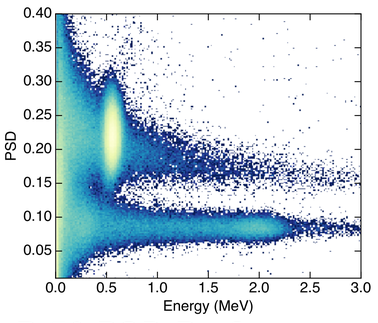
PROSPECT-50: Background and Calibration Data

Demonstrates performance of PROSPECT AD-1 design, again surpassing goals:

- **Measured Light Collection: *> 490 PE/MeV***
- **PSD Figure of Merit:**
  1.2 at (n,^{6}Li) capture peak



P-50 Light Yield

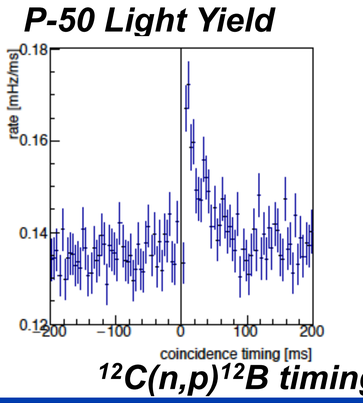


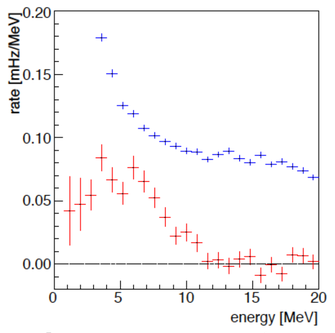
P-50 PSD Performance

Exercising calibrations systems and studying cosmogenic & radiogenic correlated backgrounds:

- **BiPo from radon decay**
- **^{12}B from cosmogenic neutron activation of ^{12}C**

May prove to be useful calibration sources





^{12}C(n,p)^{12}B timing and energy spectra

Conclusions

- **PROSPECT has developed a compact antineutrino detector design for operation close to a compact core research reactor**
- **Segmentation & ^{6}Li doping are important features for control of background**
- **A comprehensive R&D program has demonstrated that the PROSPECT ^{6}LiLS and AD-I design surpass the experiment's performance goals**
- **PROSPECT is proceeding with construction of the AD-1**

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PROSPECT Publications
arXiv: 1506.03547, 1508.06575, 1512.02202
http://prospect.yale.edu

P3.053

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